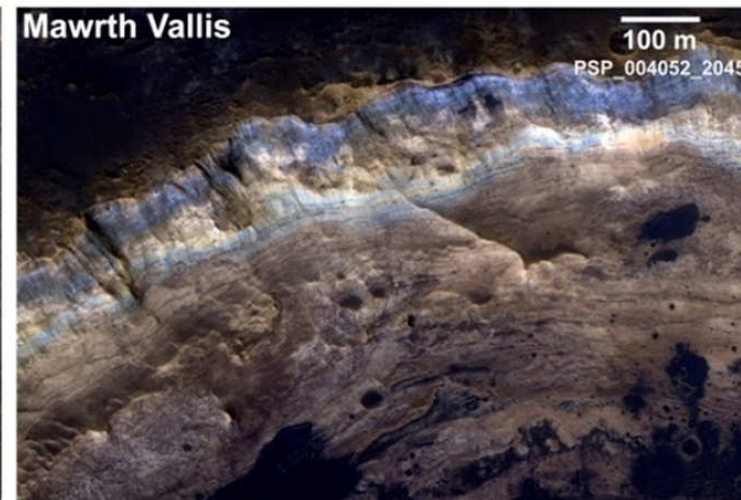


MSL Landing Site Selection Update:

Mars Landing Site Selection Activities



Matt Golombek, John Grant

(Jet Propulsion Laboratory,
California Institute of Technology)

(Smithsonian Institution)

MSL Project

J. Grotzinger, M. Watkins, A. Vasavada

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History and MSL Site Selection Milestones

Mars Landing Site Selection Activities

Started with 35 Sites

↓ 1st Workshop

New MRO data/50 sites

↓ 2nd Workshop

6 sites

↓ Steering Comm. adds 7th Site

↓ 3rd Workshop

4 sites

↓ Call for New Site

↓ 2 imaged

↓ 4th Workshop

↓ 5th Workshop

2006

Define/Refine Constraints

2007 Consider constraints where possible
(e.g., rock abundance)

2008

Consider Engineering constraints

2009

Limited Ongoing Studies

2010

Engineering Studies

2011

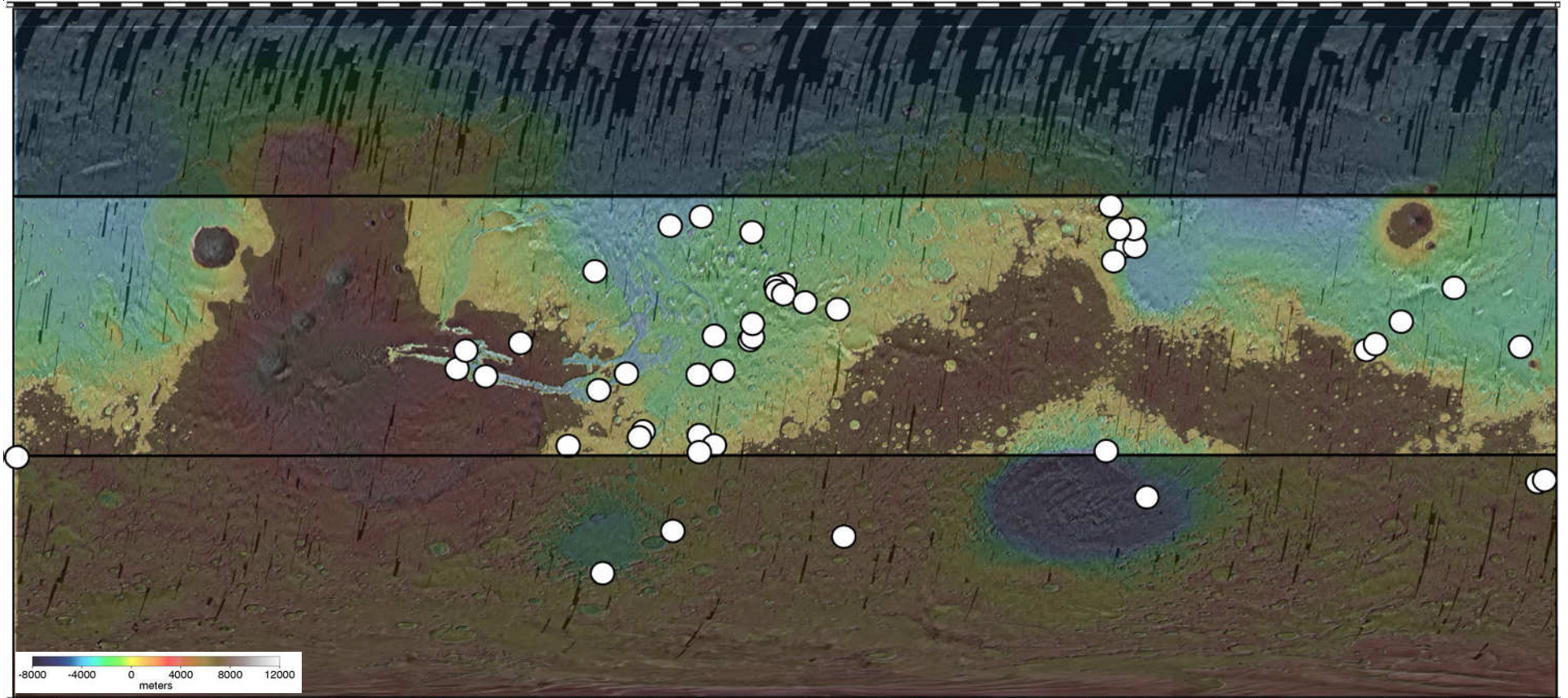
Mature Engineering constraints

(e.g., wheel actuators)

NASA HQ Selection Spring 2011

~50 Proposed MSL Landing Sites

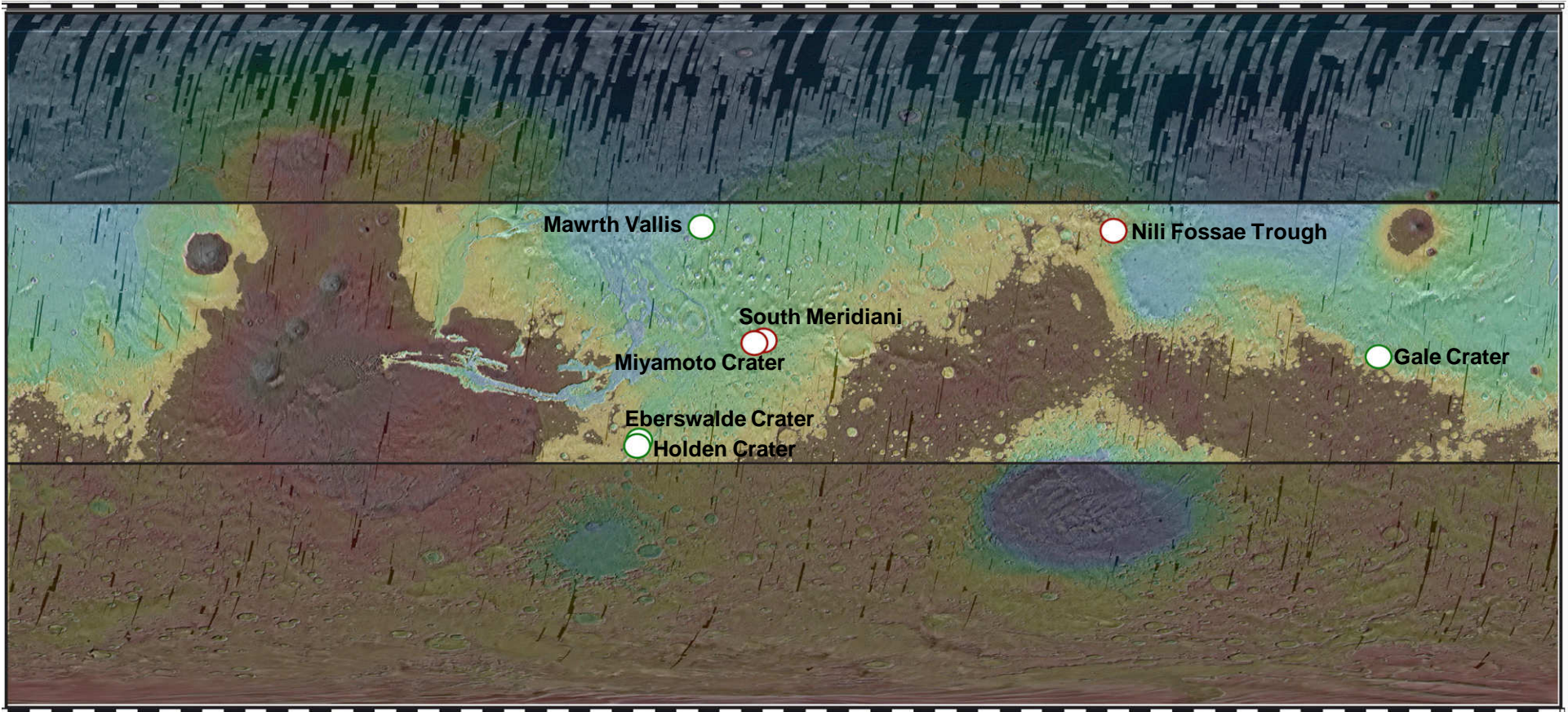
Mars Landing Site Selection Activities



Shaded areas are above +30°N, below -30°S, and above +1 km in elevation

Seven Downselected MSL Landing Sites:

Mars Landing Site Selection Activities



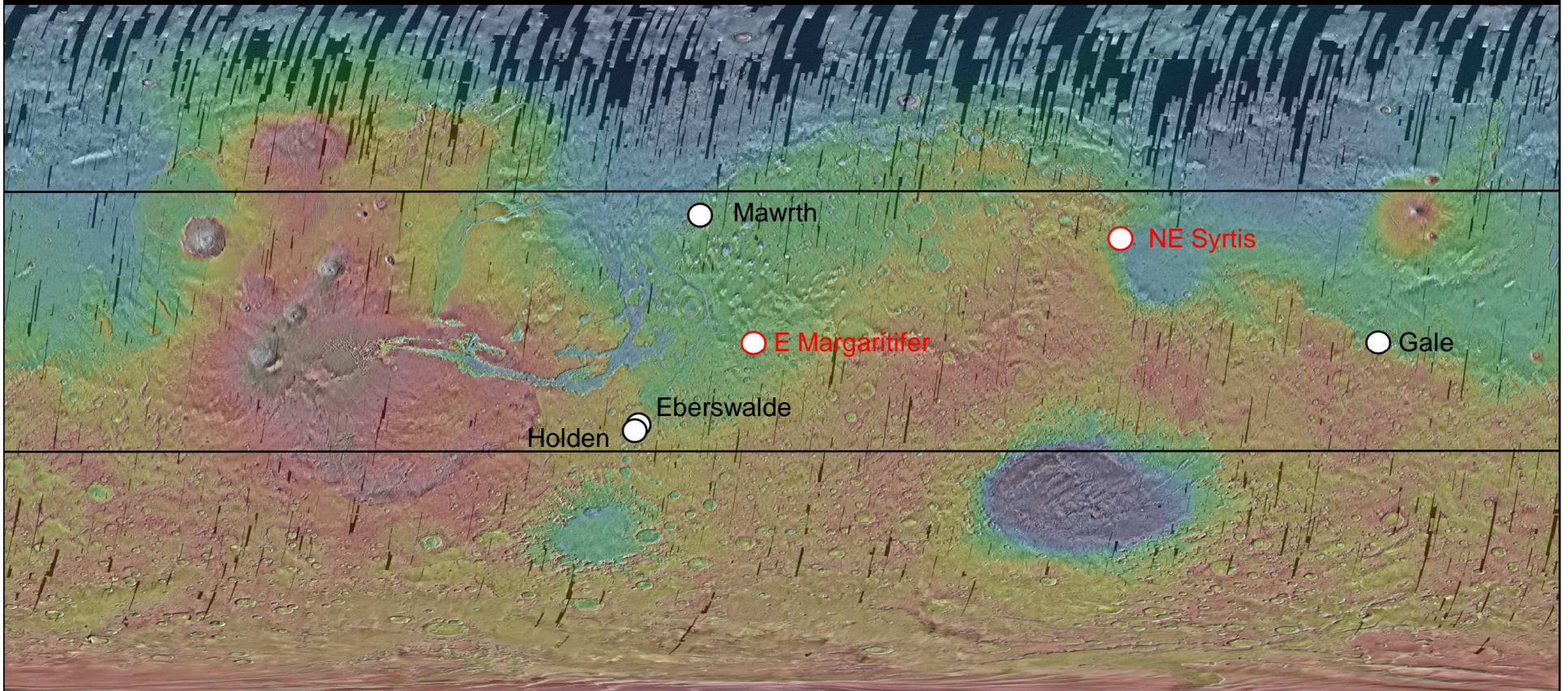
Seven Sites Receiving Highest Science Ranking:

Shaded areas above $+30^{\circ}\text{N}$ and -30°S , elevations >1 km

Green outlines denote final four sites based on science, engineering

MSL Landing Sites

Mars Landing Site Selection Activities



Four Sites: Mawrth, Gale, Eberswalde, Holden

Potential New Sites: NE Syrtis, E Margaritifer

Call for & Review of New MSL Site Candidate Sites:

Mars Landing Site Selection Activities

Call for new sites in Fall, 2009 (August, reminder in October)

- As compelling as existing candidate sites
- Mature Interpretation of Setting at Candidate Sites
- 5 Sites Evaluated for Consideration
- Reviewed/Prioritized by Steering Committee
- 2 Sites Recommended for Further Study, Dec. 2, 2009
- NE Syrtis and E Margaritifer

Imaged 2 Sites with MRO & Other Orbiters

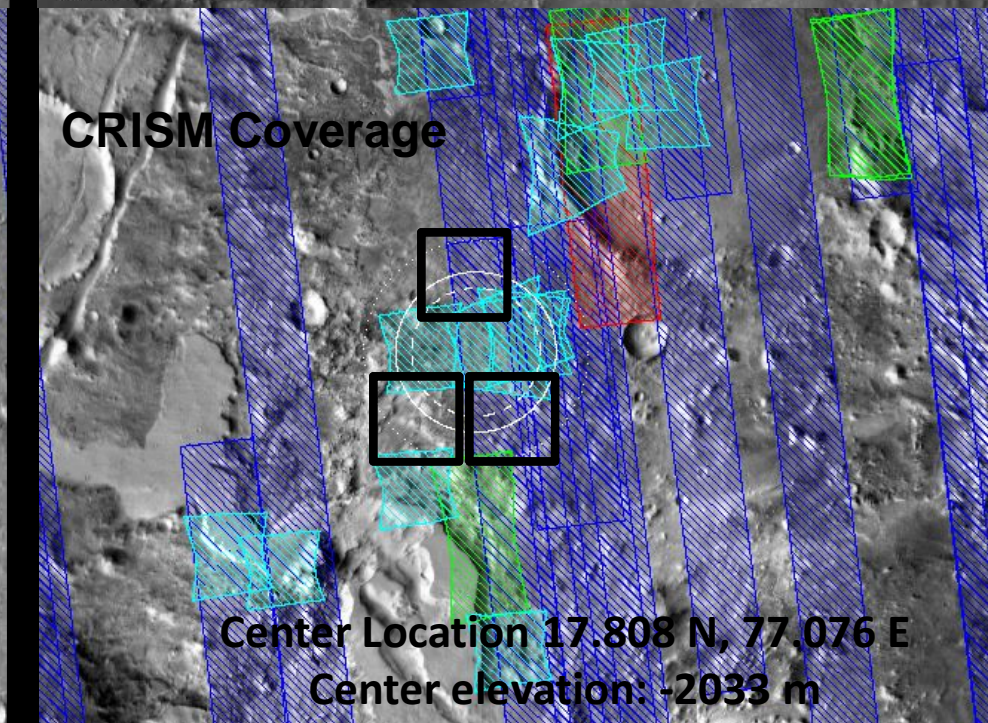
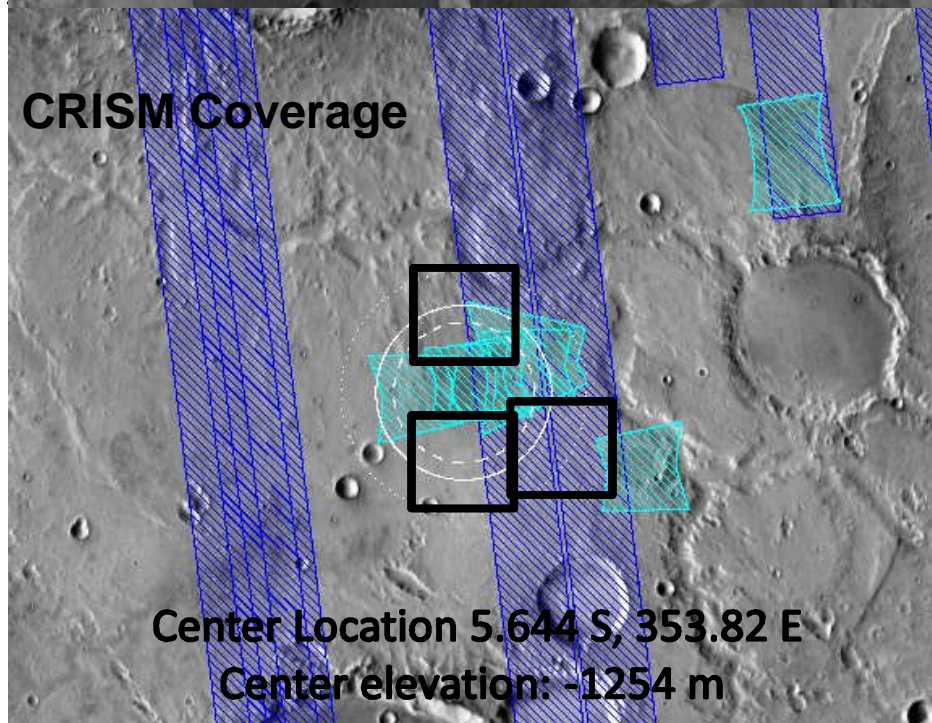
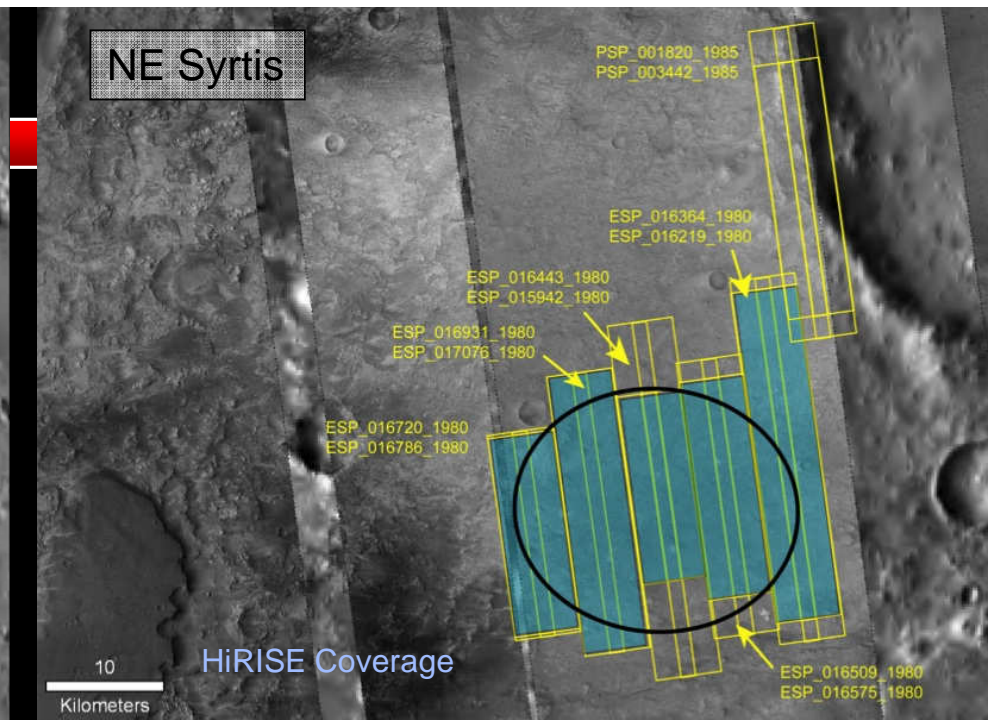
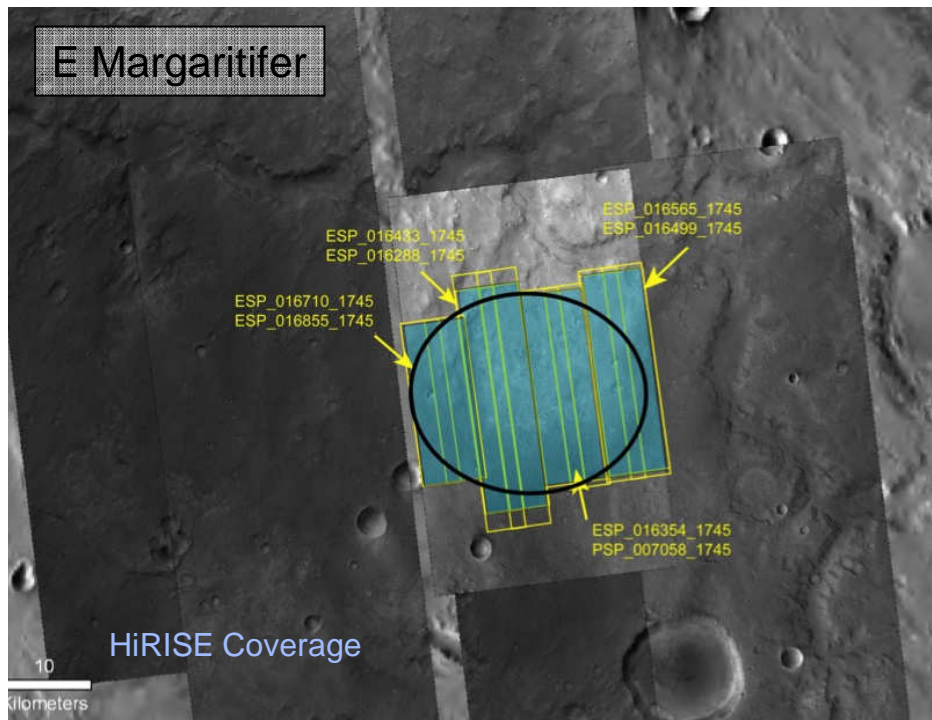
- Substantial HiRISE & CRISM Coverage Obtained

2 Sites Evaluated by Steering Committee and Project, May 4, 2010

- NE Syrtis As compelling as existing candidate sites
- Significant Safety Concerns at Both
- Steering Committee Recommended Neither Site be Added
- Project Did Not Add Either

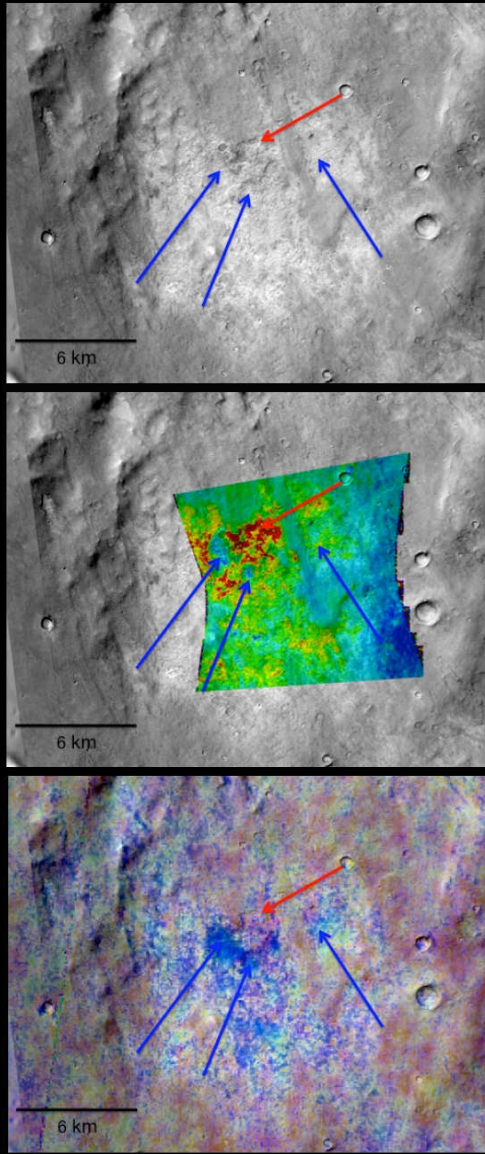
4 Sites Remain

- Gale, Holden, Mawrth, Eberswalde

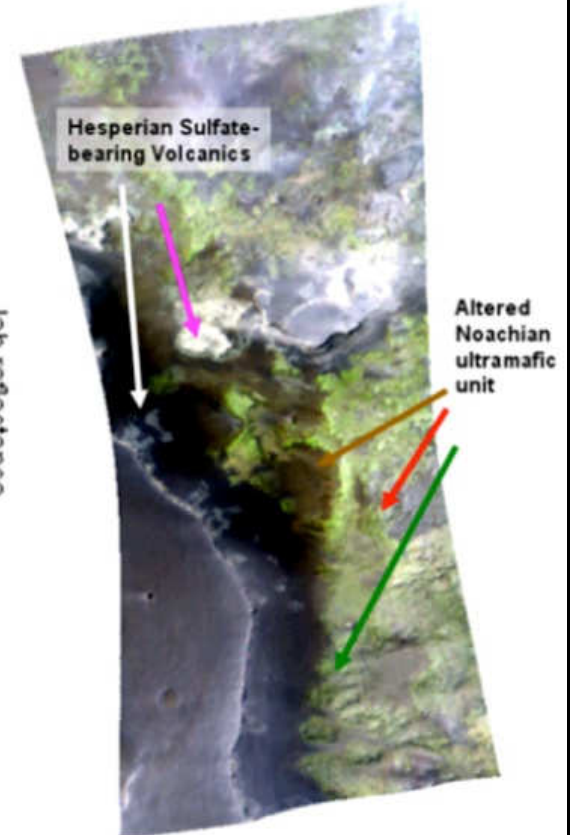
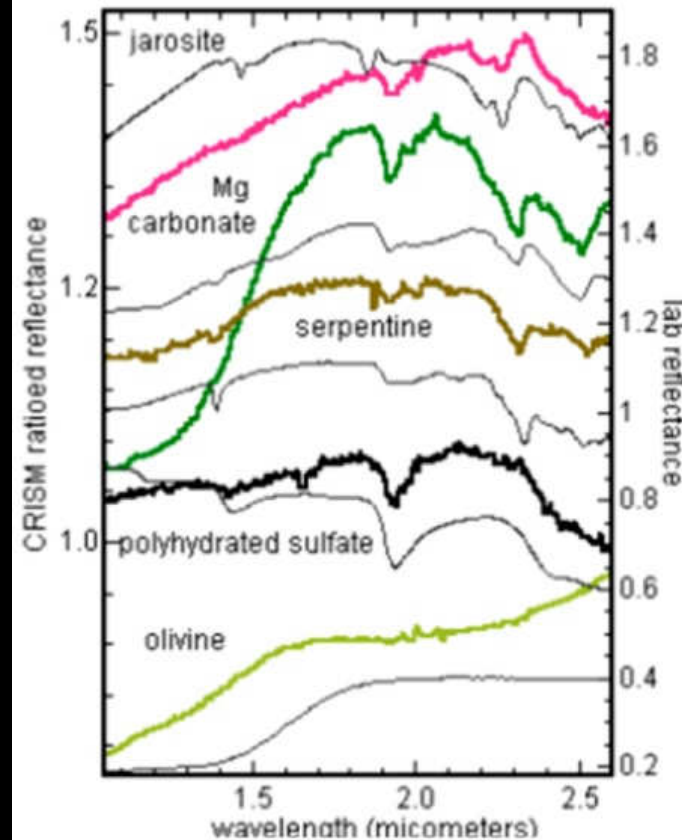


A Thumbnail View of 2 Potential Sites:

Mars Landing Site Selection Activities

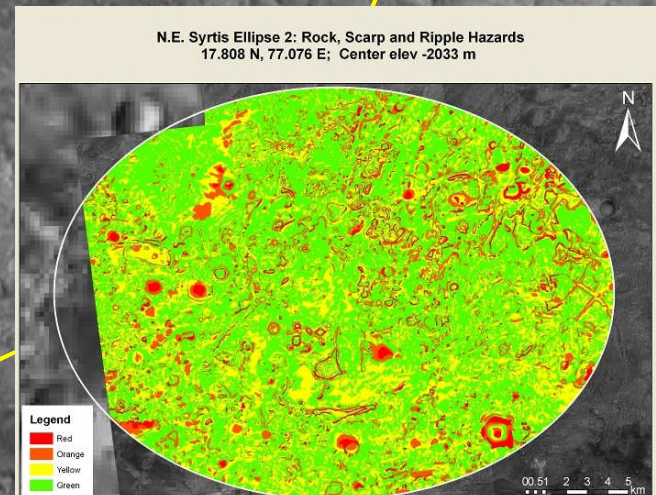
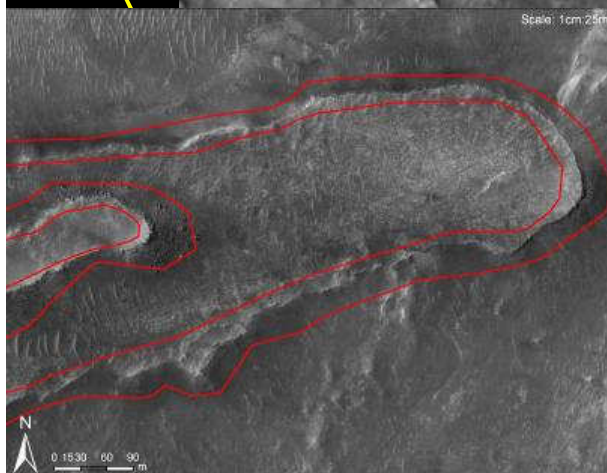


East Margaritifer
Chloride, Phyllosilicates



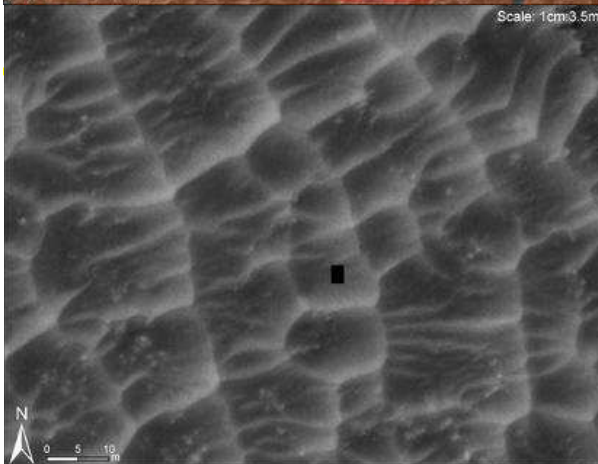
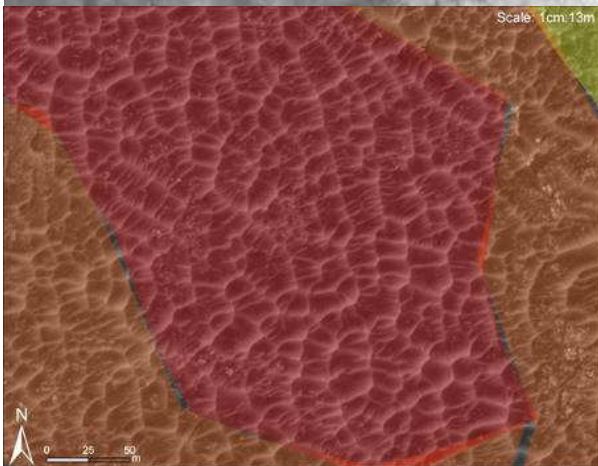
NE Syrtis
Diverse Aqueous Minerals
At H-N Boundary

- NE Syrtis Ellipse 2
- Mesas, Hills & Rocks



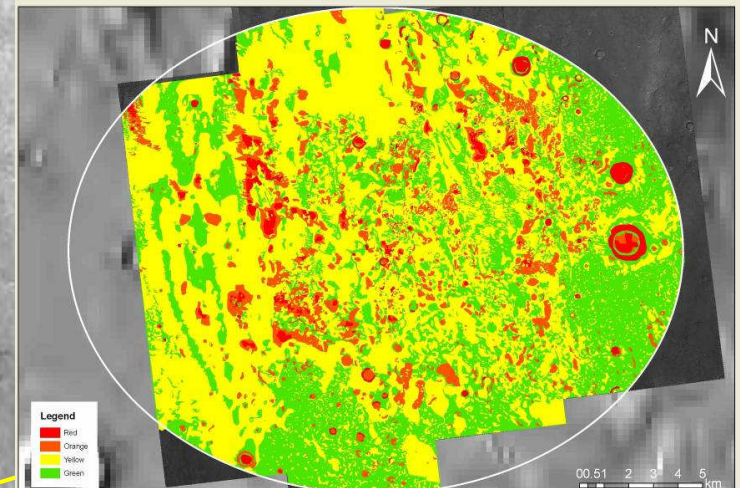
Surface Characteristics MSL Sites

- E Margaritifer Ellipse
- Ellipse Relatively Smooth & Flat
 - Large Ripple Fields
 - May be Inescapable



Surface Characteristics MSL Sites

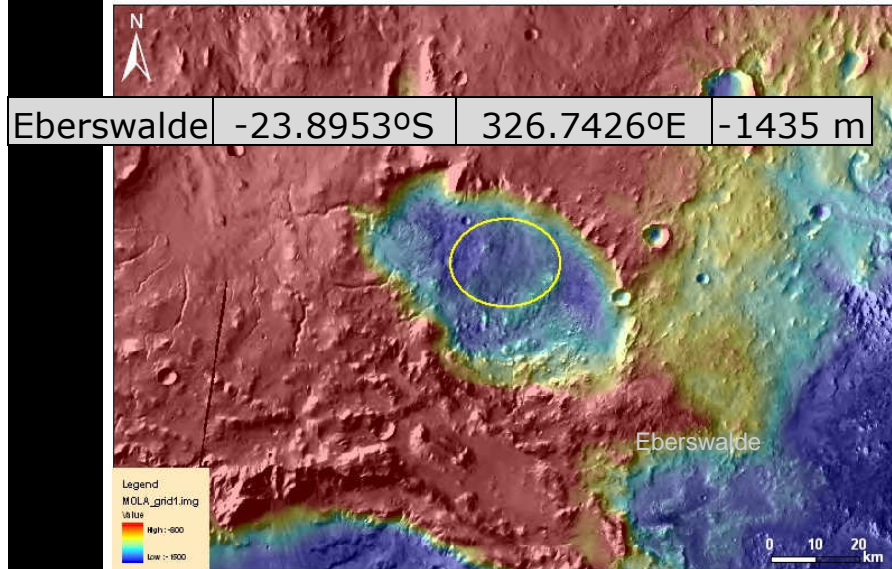
Eastern Margaritifer: Rock, Scarp and Ripple Hazards
5.644 S, 353.82 E; Center elev -1254 m



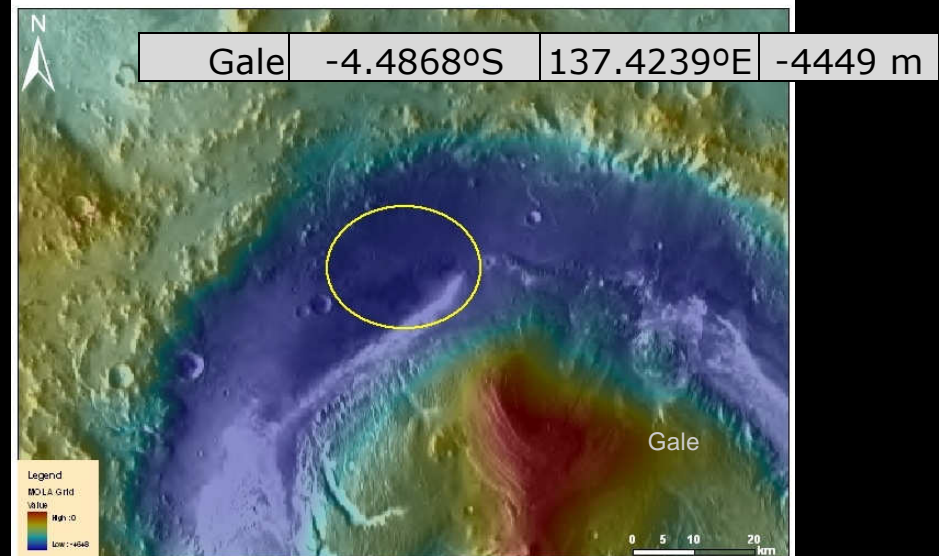
Final Four MSL Landing Ellipses

Mars Landing Site Selection Activities

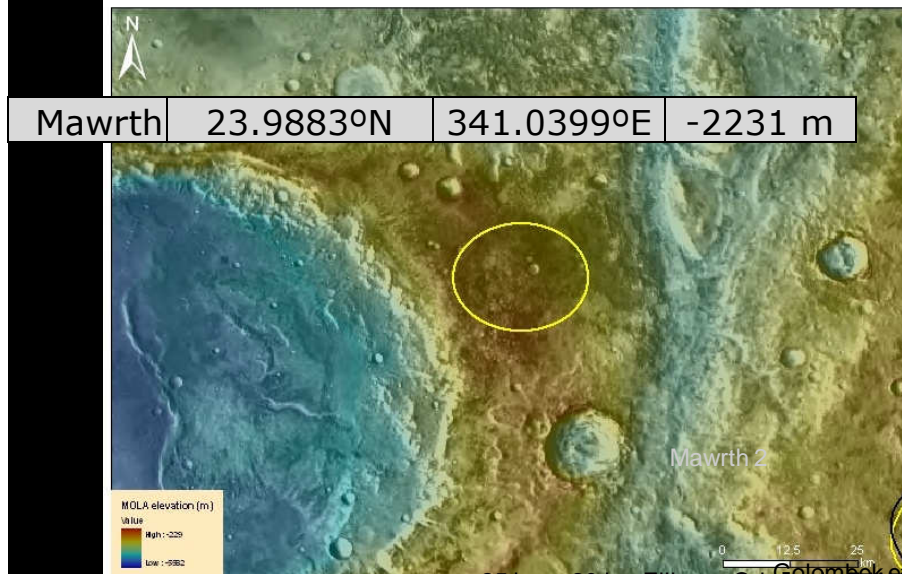
Eberswalde Crater: MOLA



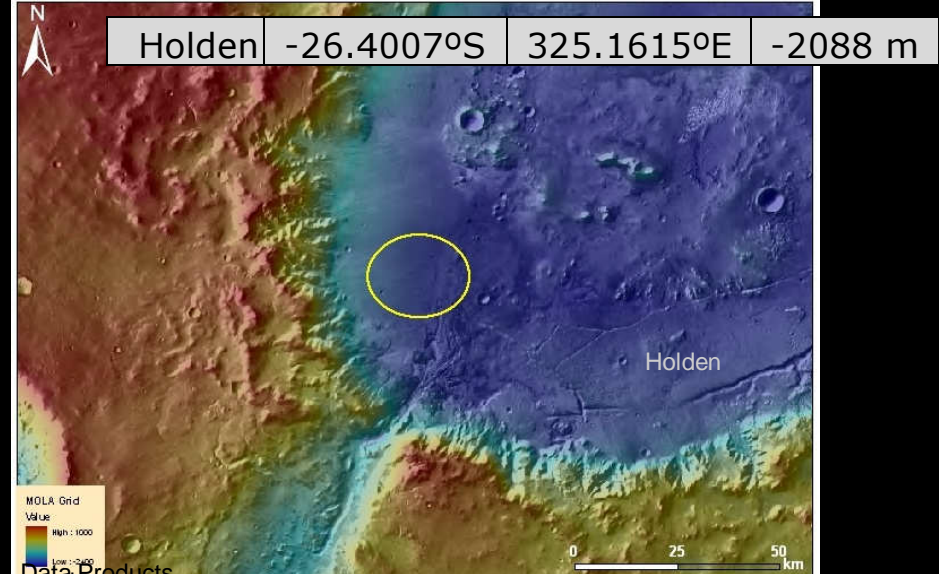
Gale Crater: MOLA



Mawrth Vallis Site 2: MOLA



Holden Crater: MOLA



25 km by 20 km Ellipses E-W for 2011

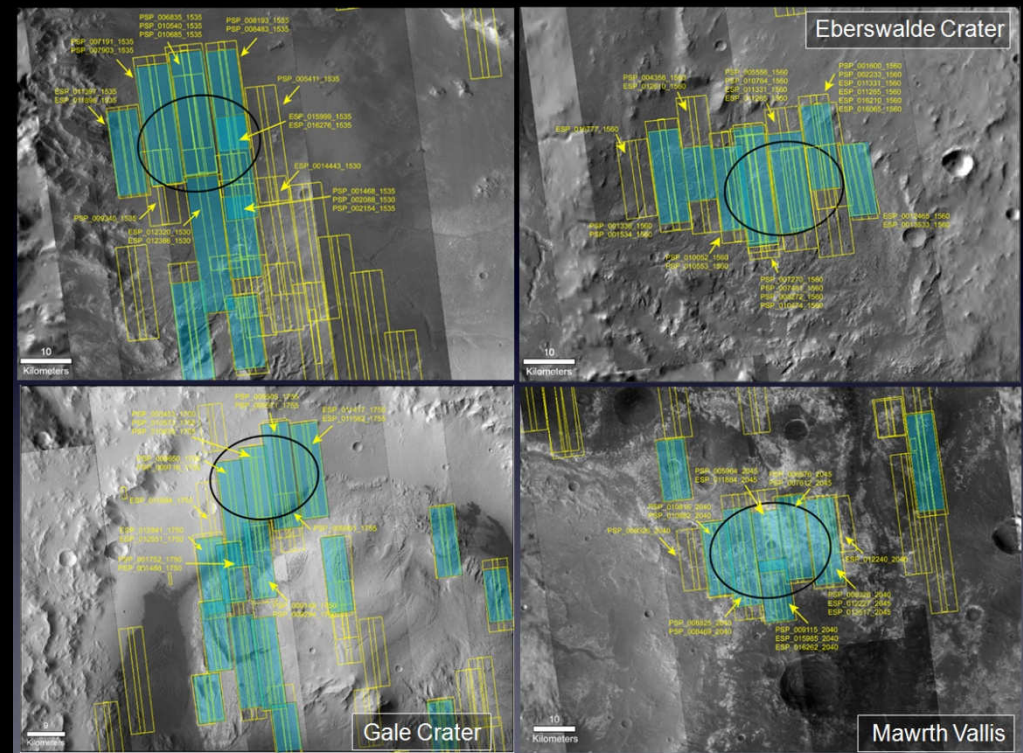
Evaluating Candidate MSL Landing Sites:

Mars Landing Site Selection Activities

Current orbital assets have set the new standard for data required for identifying and qualifying new Mars landing sites

An incredible effort by instrument teams has gone into obtaining high quality data used to evaluate candidate sites

VIKING	Pathfinder	MER	MSL
			HiRISE
			CRISM
			CTX
			MCS
			MER
			SHARAD
			MARSIS
			OMEGA
			HRSC
		THEMIS	THEMIS
		MOC	MOC
		TES	TES
		MOLA	MOLA
		Pathfinder Site	Pathfinder Site
		Viking Landing Sites	Viking Landing Sites
		Earth-based Radar	Earth-based Radar
		Viking IRTM	Viking IRTM
		Viking Images	Viking Images
Viking IRTM	Viking Landing Sites		
Viking Images	Earth-based Radar		
	Viking IRTM		
	Viking Images		

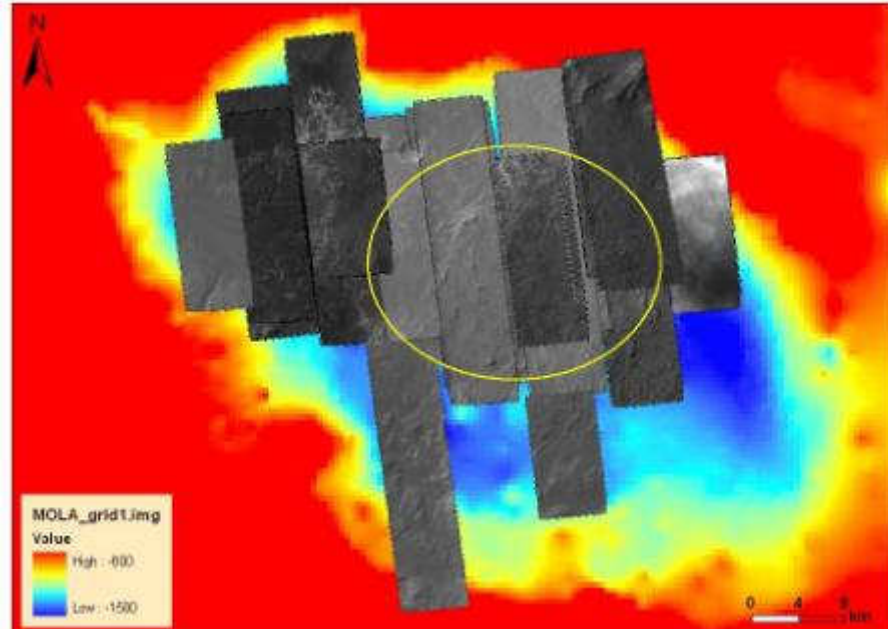


More than 200 MRO Observations of Candidate Landing Sites to Date!

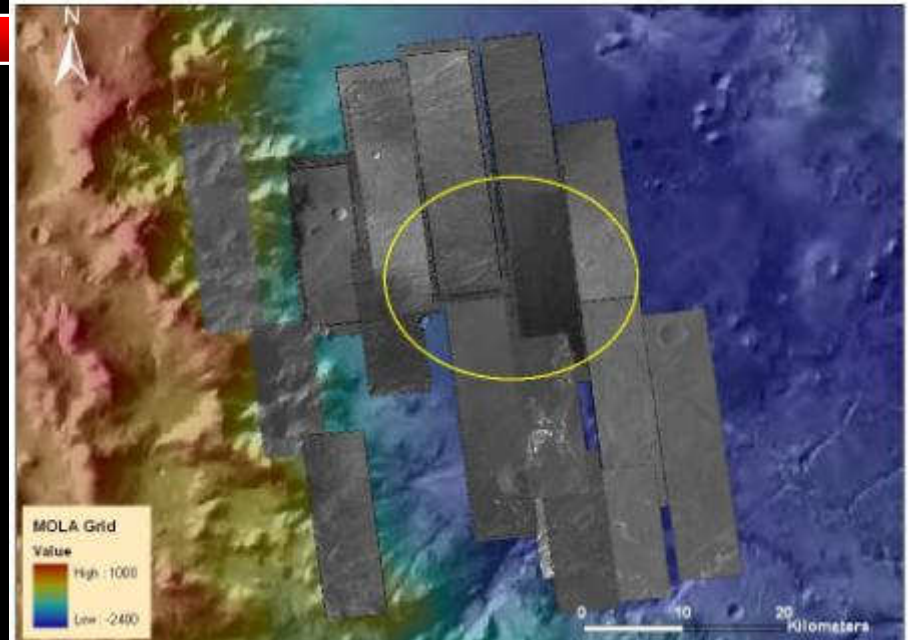
HiRISE Image Coverage in Ellipse

Ellipses Exact
Images Georeferenced

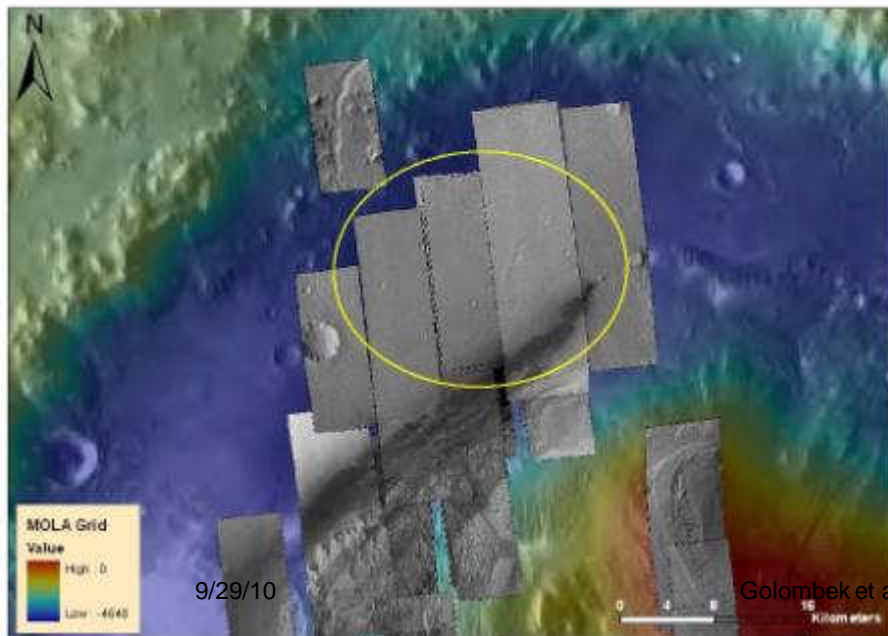
Eberswalde Crater HiRISE



Holden Crater HiRISE Images Georeferenced

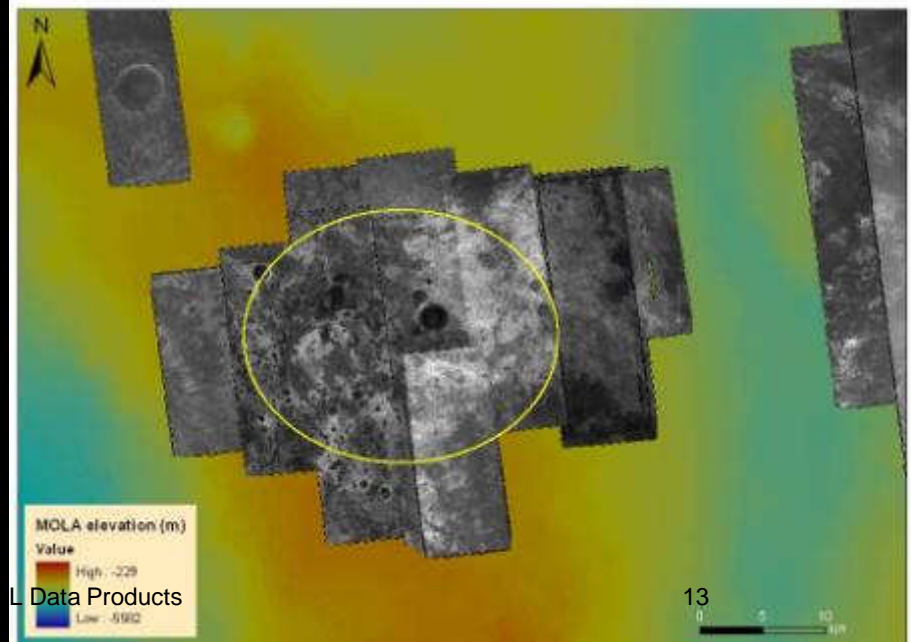


Gale Crater HiRISE



Mawrth Vallis HiRISE

Sun & Slad



9/29/10

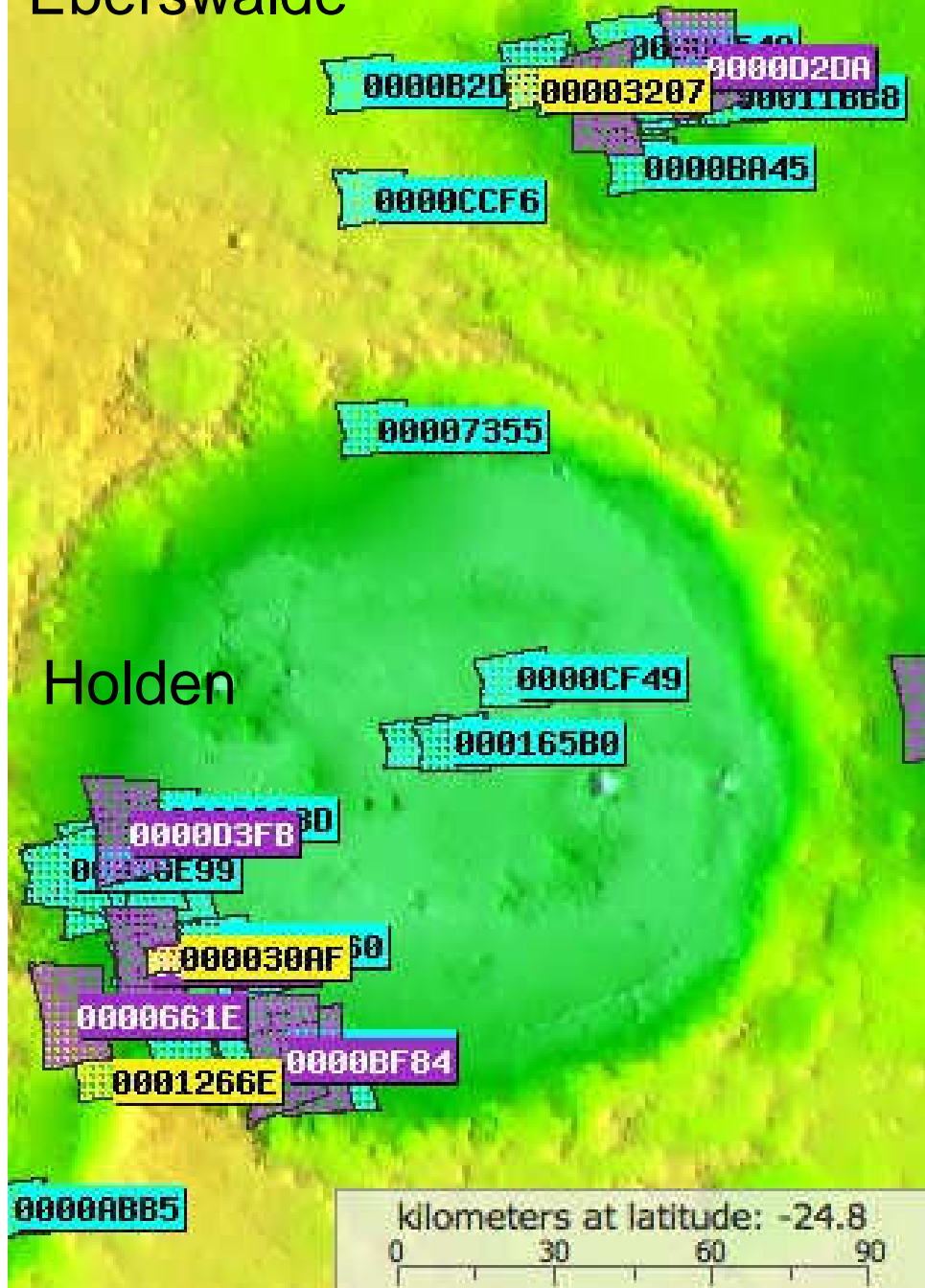
Golombek et al

L Data Products

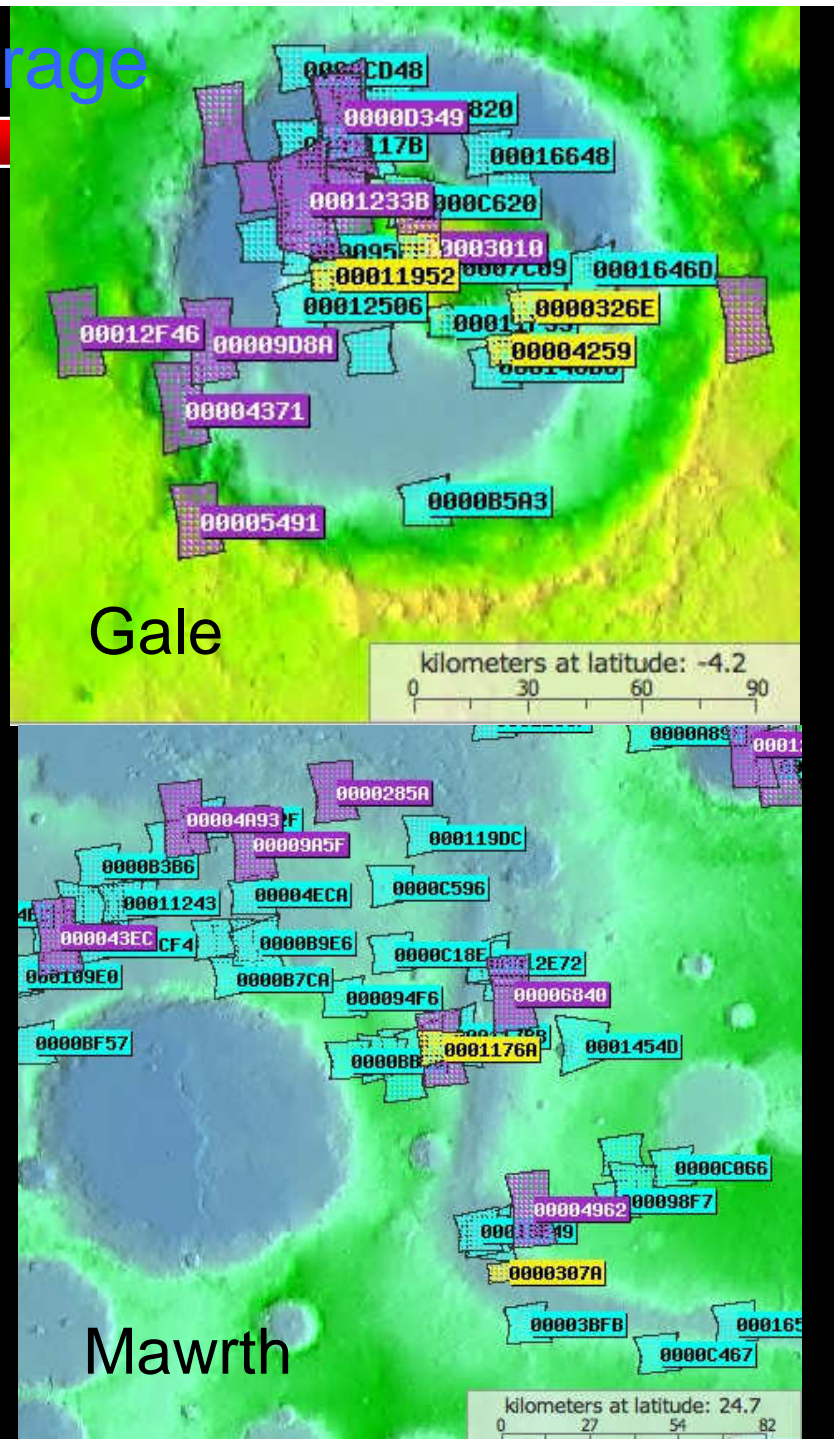
13

Eberswalde

CRISM Coverage



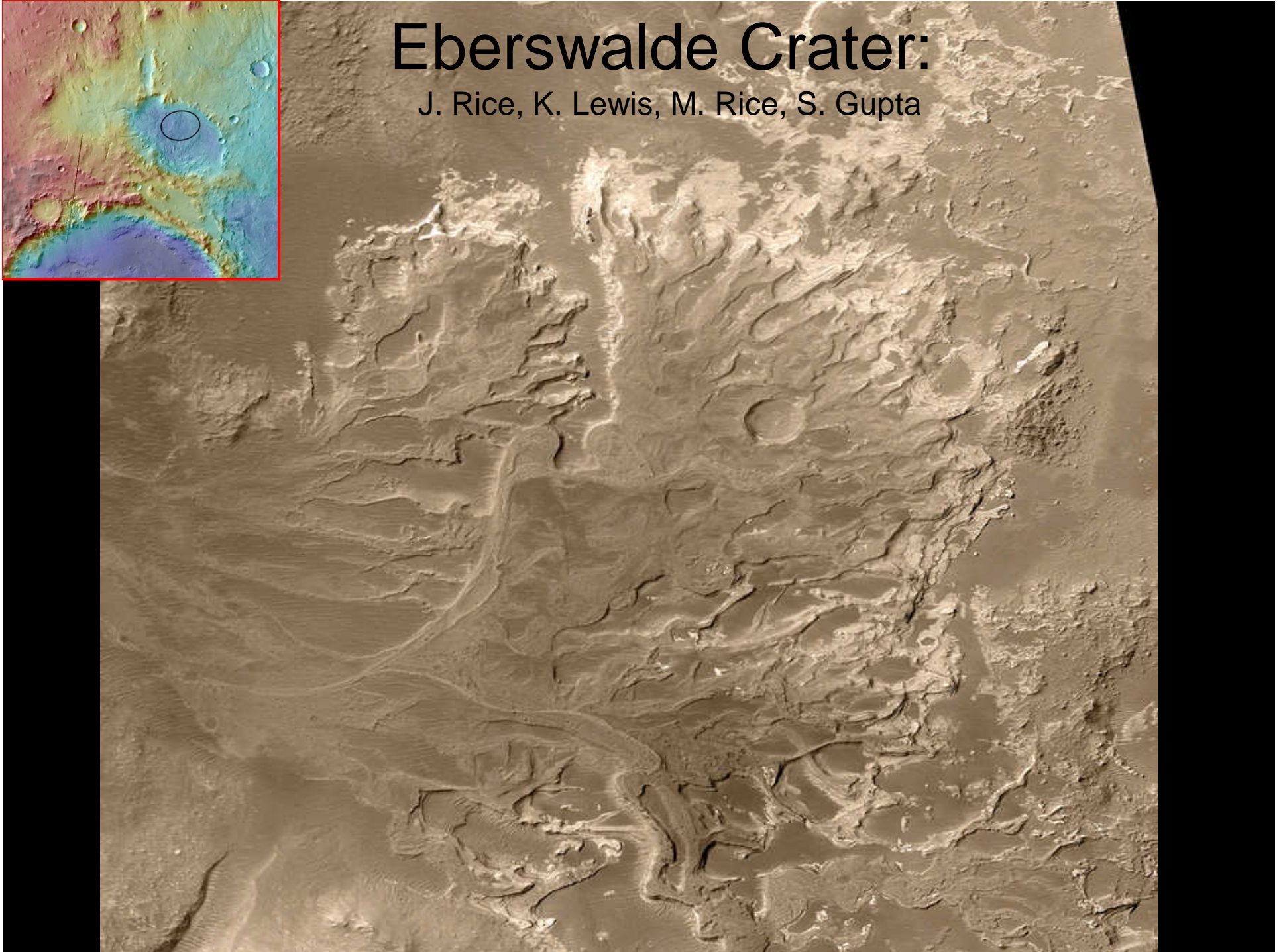
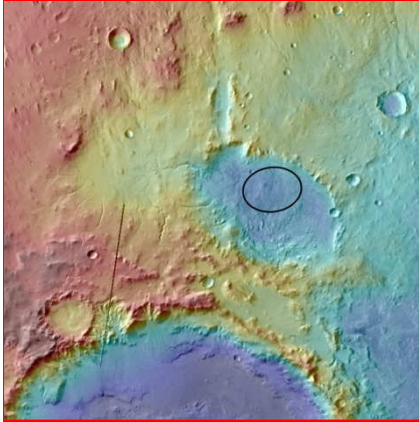
Gale



Mawrth

Eberswalde Crater:

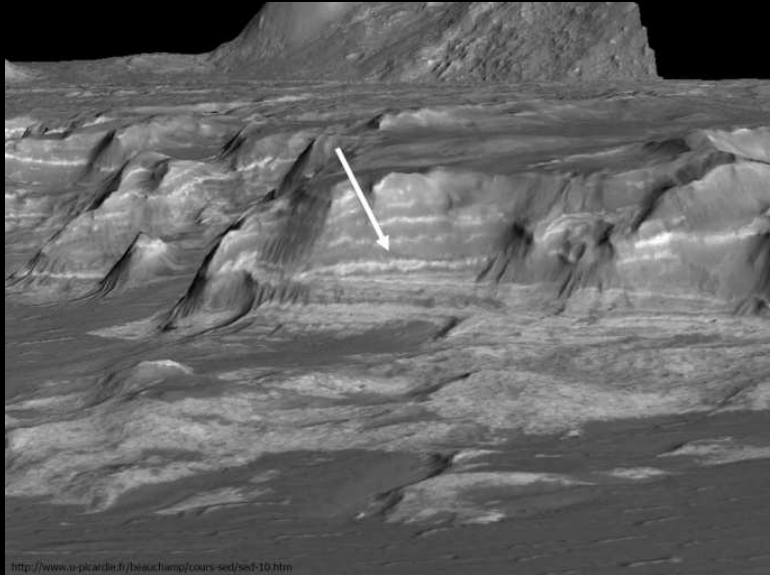
J. Rice, K. Lewis, M. Rice, S. Gupta



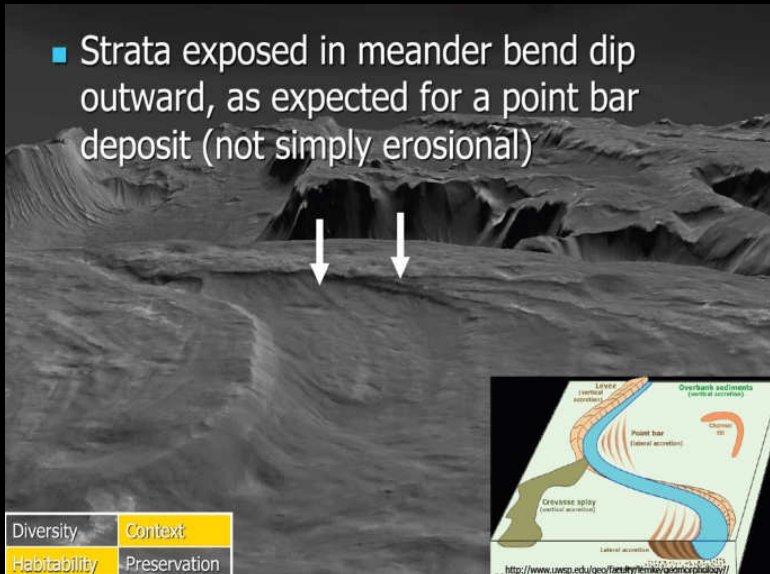
Clay-Bearing Beds in Deltaic Setting:

Mars Landing Site Selection Activities

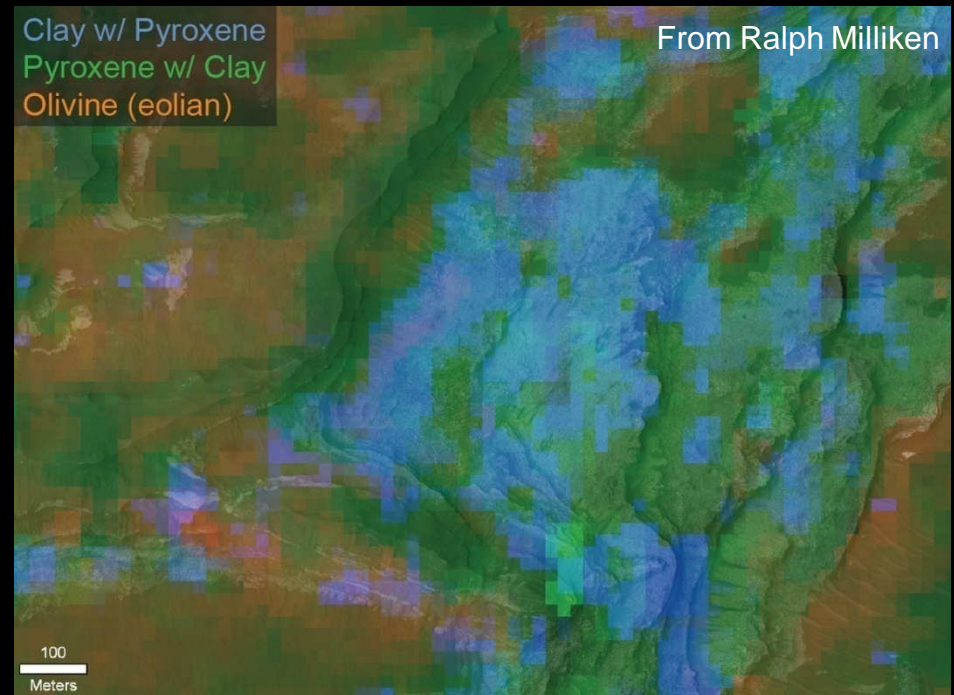
Eberswalde



- Strata exposed in meander bend dip outward, as expected for a point bar deposit (not simply erosional)



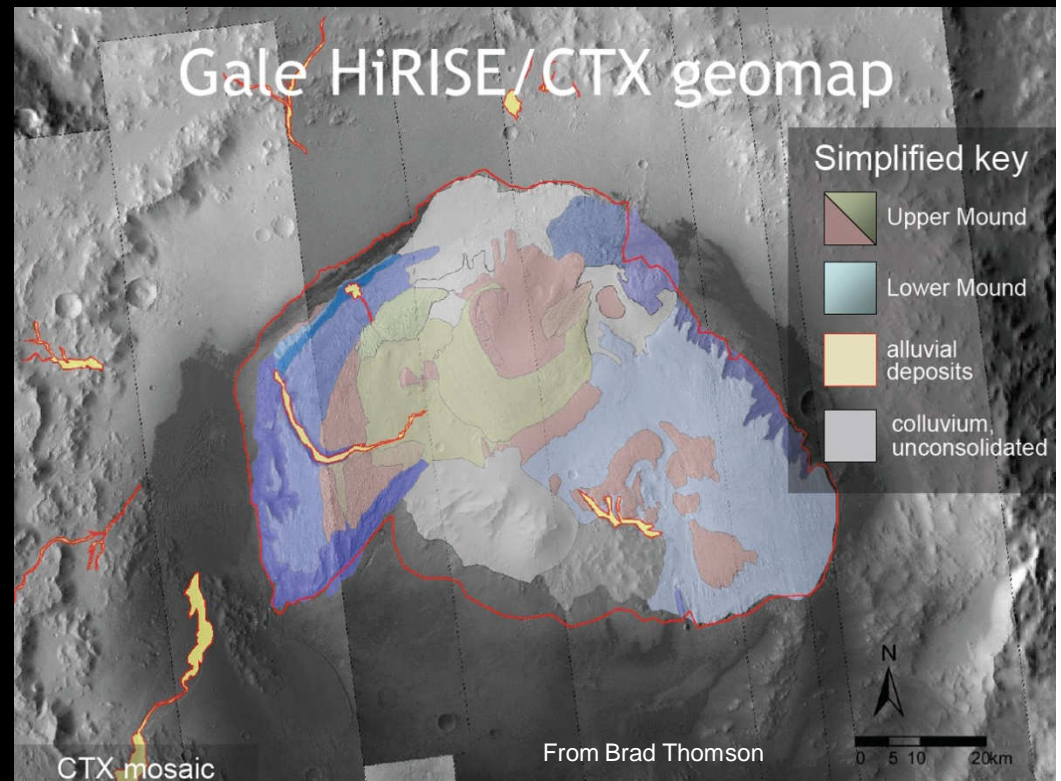
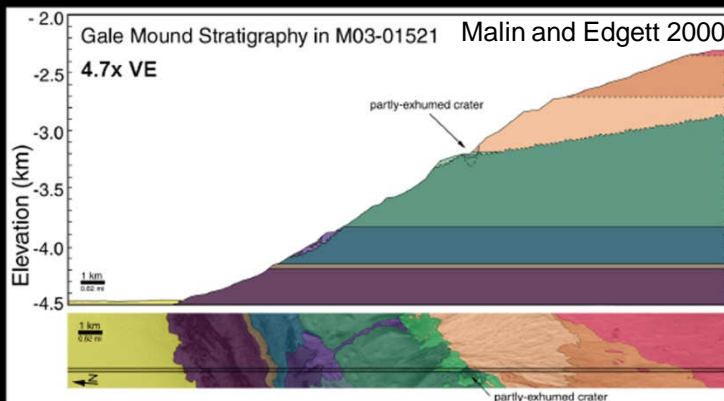
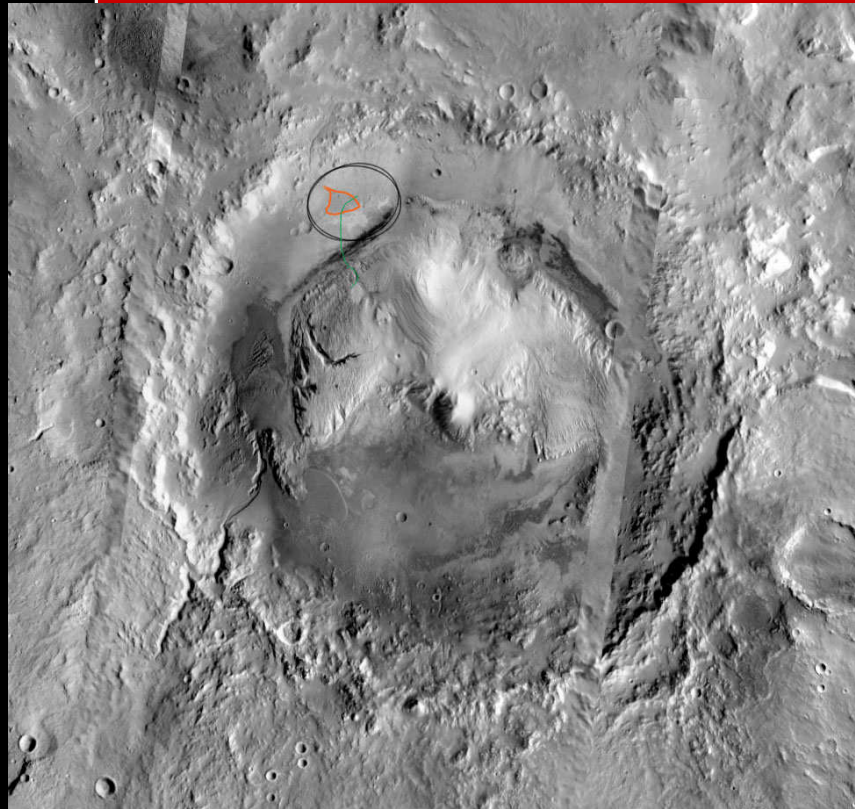
Diversity	Context
Habitability	Preservation

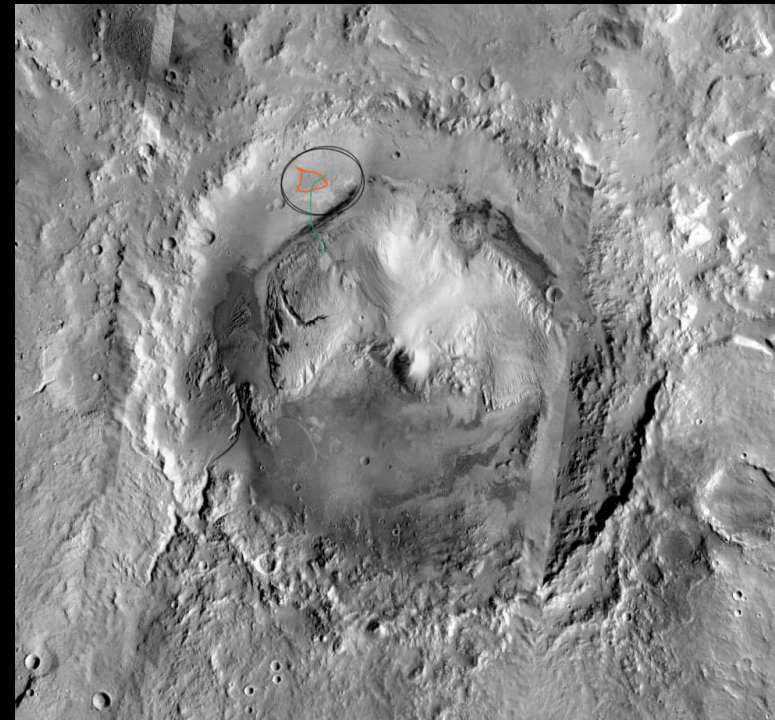
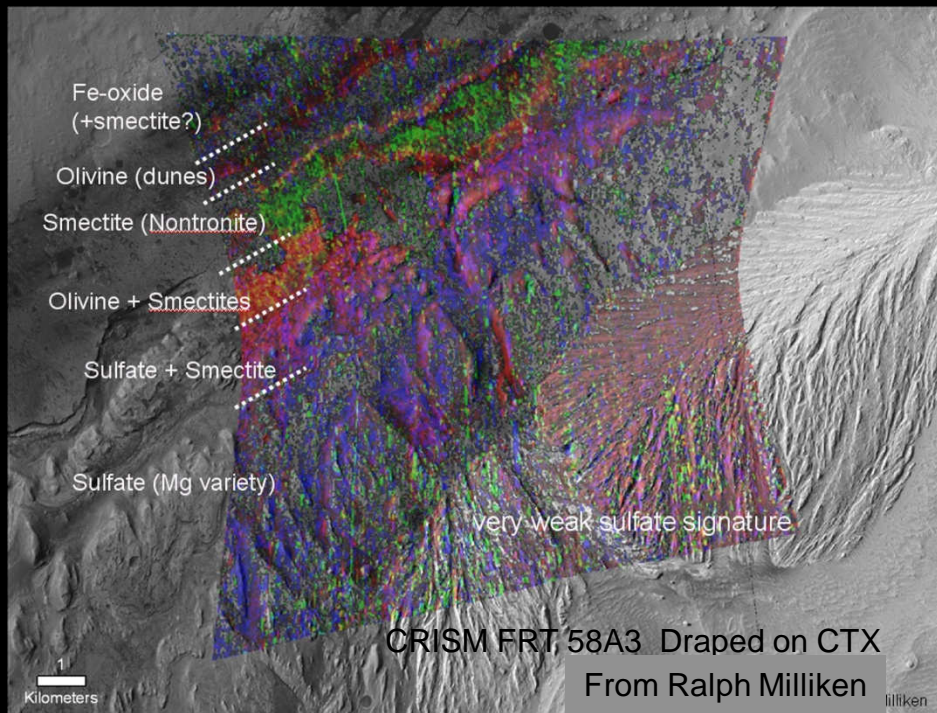


Gale Crater: K. Edgett, R. Anderson, J. Bell, D. Sumner, R. Milliken

Mars Landing Site Selection Activities

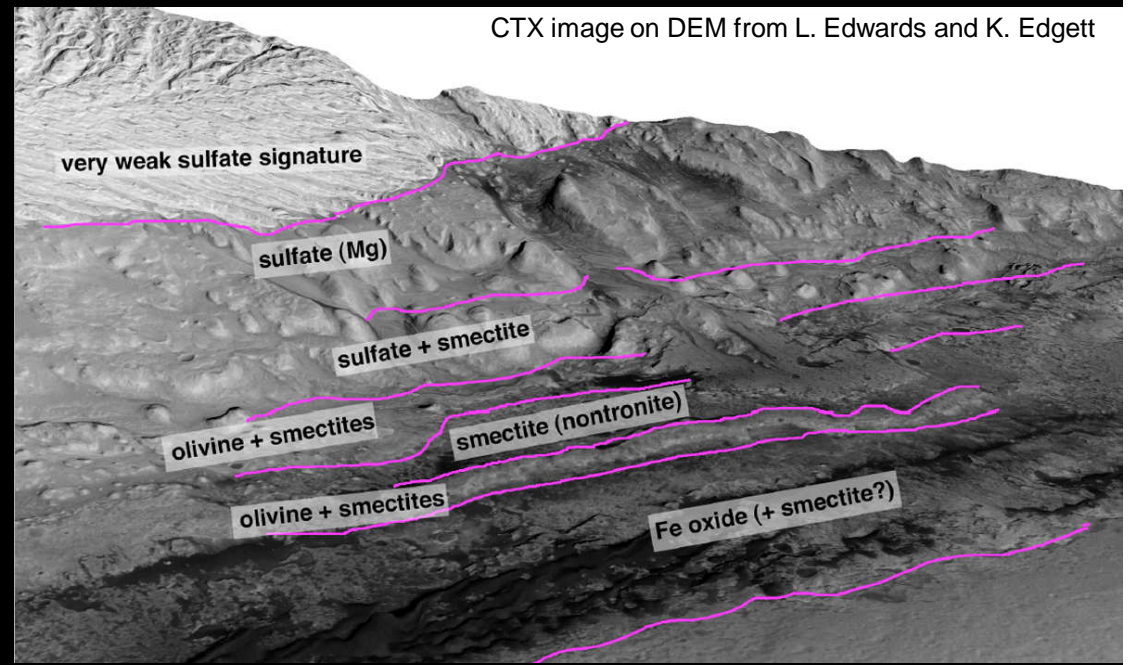
- High diversity of geologic materials with different compositions and depositional conditions
- This diversity is arranged in a stratigraphic context
- Stratigraphy records multiple early Mars environments in sequential order
- Gale is characteristic of a family of craters that were filled, buried, and exhumed, providing insights into an important martian process



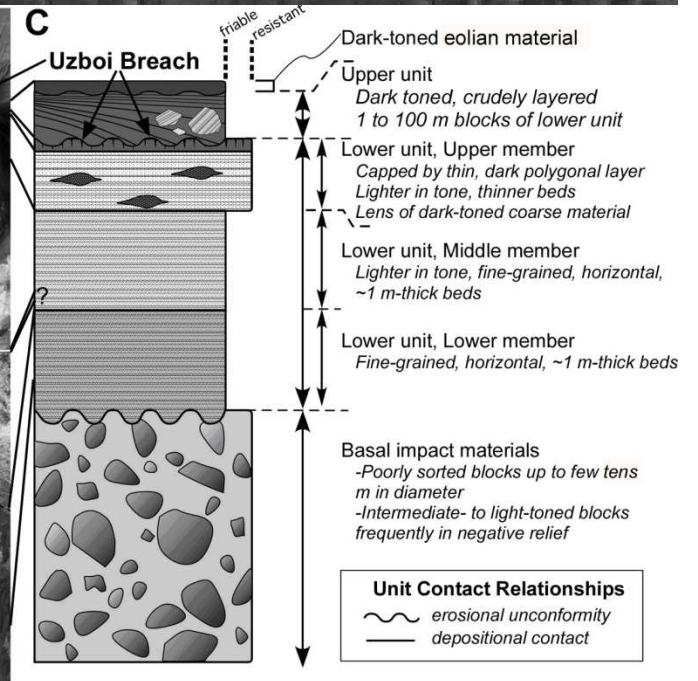
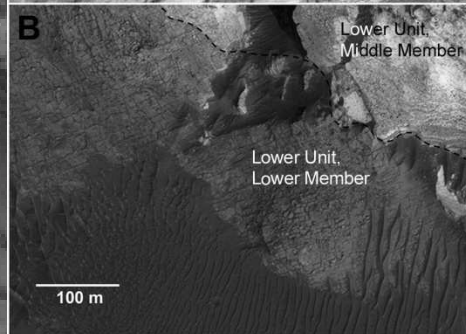
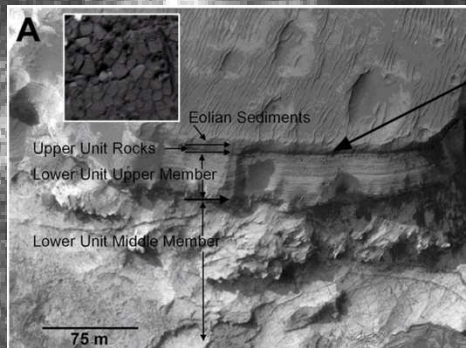
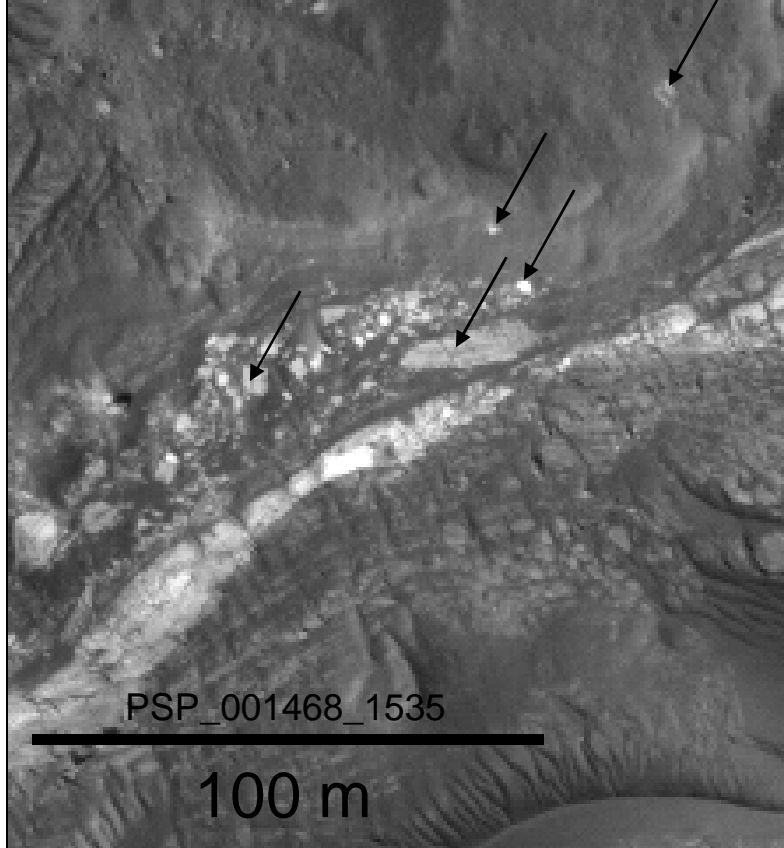
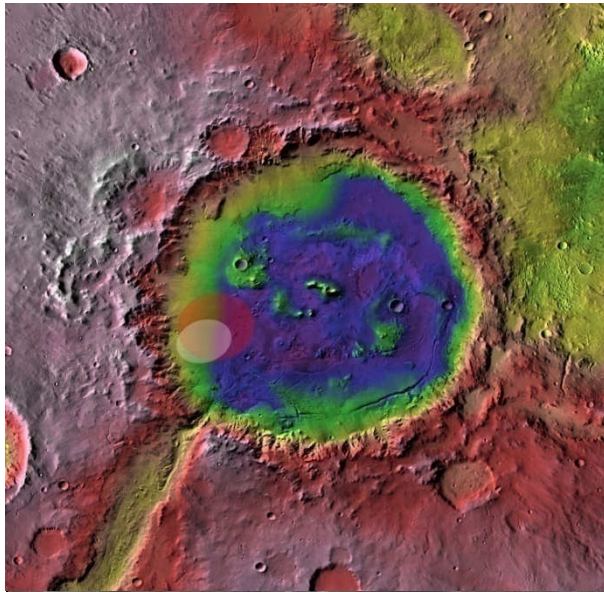


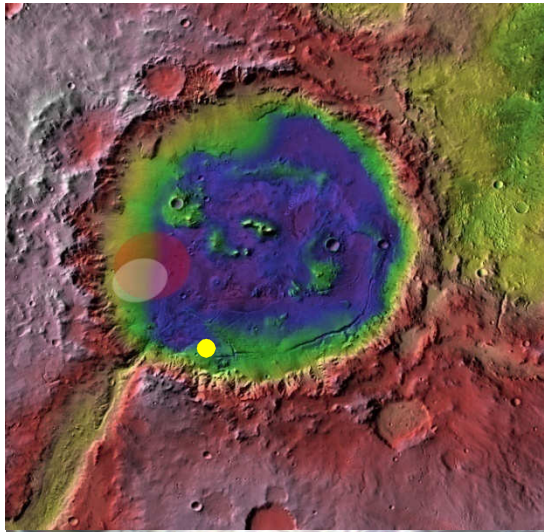
CTX image on DEM from L. Edwards and K. Edgett

Gale Crater



Holden Crater: R. Irwin, K. Whipple, J. Wray

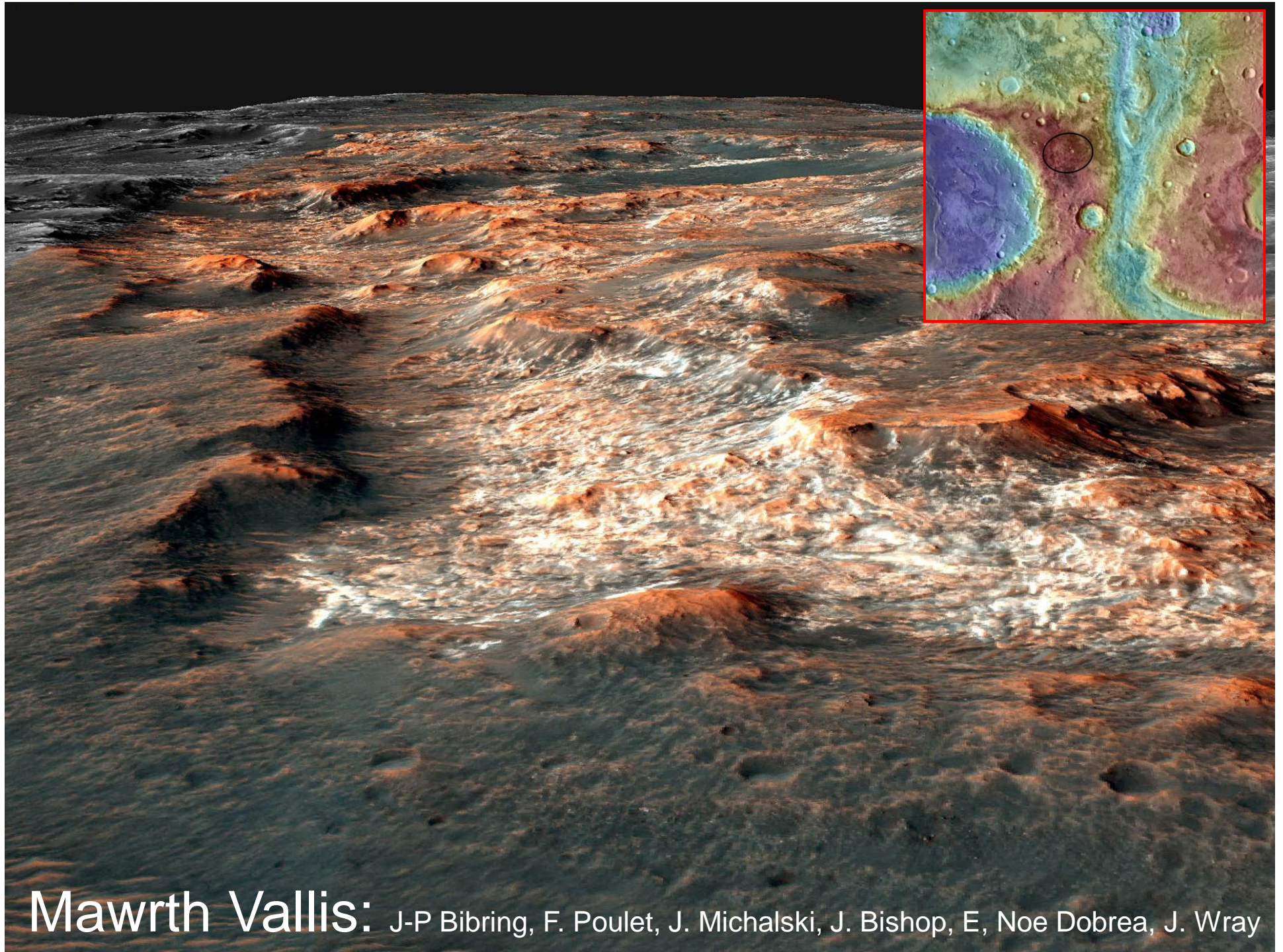




Holden Crater



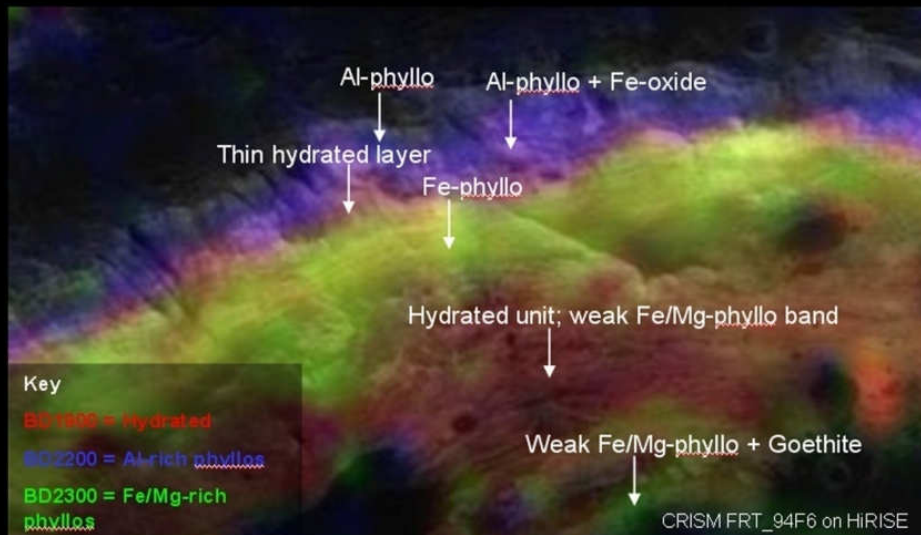
Holden Crater



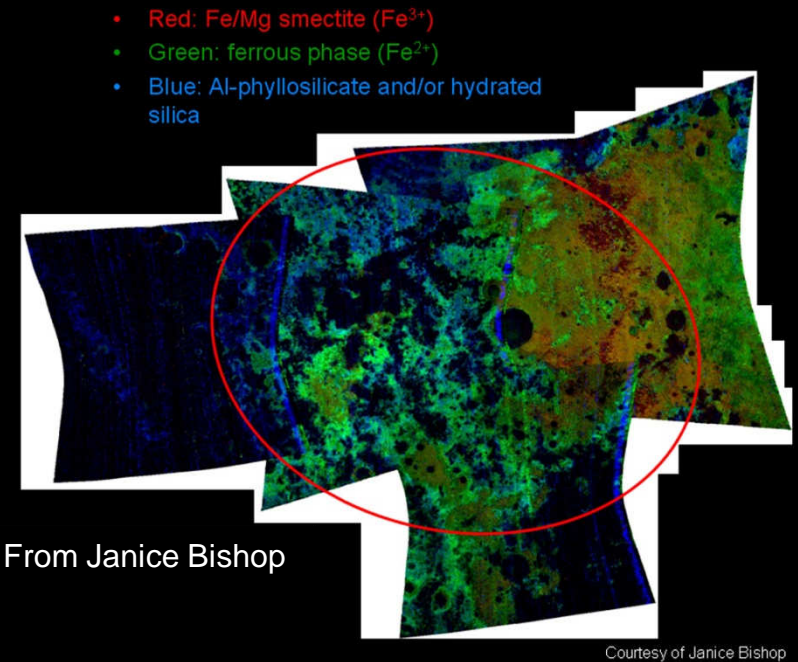
Mawrth Vallis: J-P Bibring, F. Poulet, J. Michalski, J. Bishop, E. Noe Dobrea, J. Wray

Mawrth Vallis: Phyllosilicate-Bearing Stratigraphy within the Landing Ellipse:

Mars Landing Site Selection Activities



From James Wray



4th MSL Landing Site Workshop 9/27-29

Mars Landing Site Selection Activities

Extensive Discussion on Science & Surface Characteristics

Sessions

Introduction; Habitability & Biosignatures ; CRISM Mineralogy
Gale Crater; Mawrth Vallis; Holden Crater; Eberswalde Crater
Characterization

Presentations Posted on Landing Site Web Sites

Summary Community Statements on Each Landing Site

Hypothesis, Attributes wrt Science Objectives of MSL,
Future Efforts

See Landing Site Websites for Postings

All Sites Scientifically Compelling

All Sites "Safe" for Landing

Rover Traversability to be Discussed at 5th Workshop

Gale Crater

Mars Landing Site Selection Activities

Overarching Hypothesis

Strata in Mound Reflect Sequence Aqueous Habitable Environments

Setting

- 5 km Mound, Stratigraphy Hydrated Minerals Reflects Changing Environmental Conditions
- Ellipse Contains Alluvial Materials from Walls

Diversity

- Multiple Mineralogical/Stratigraphic Units - Phyllo & Sulfate

Preservation

- Phyllo & Sulfates may contain & preserve organics

Future Efforts

- Better define depositional setting, stratigraphy/mineralogy
- Context of Mound wrt Global Stratigraphic Framework
- Define Location of Preserved Organics
- Science Targets in Ellipse

Mawrth Vallis

Mars Landing Site Selection Activities

Overarching Hypothesis

Habitability in Early Mars Aqueous Environment - Phyllosilicates

Setting

- Oldest Preserved Layered Stratigraphic Section on Mars
- Numerous materials formed in Aqueous Environment, representative of early Mars; Overlying Hesperian Cap

Diversity

- Diverse Mineralogical/Stratigraphic Units Aqueous Environments
- Diagenetic, pedogenic, impact fluvial processes

Preservation

- Several Locations in Close Proximity - Record Early Conditions

Future Efforts

- Better definition of Age using Crater Statistics; Stratigraphy
- Depositional Setting-Importance of Impact
- Potential Targets Outside of Ellipse

Holden Crater

Mars Landing Site Selection Activities

Overarching Hypothesis

Fluvial Lacustrine System in Habitable Environment

Setting

-Fans in Ellipse, Layered Materials Large, Preserved Aqueous Environment

Diversity

-Diverse Fan, Layered Sediments, Flood Deposits & Megabreccia
-Mineralogical diversity-altered/primary compositions

Preservation

-Layered deposits may be bottomset, lake beds

Future Efforts

-Stratigraphy of Fans & Layered Deposits
-Define Depositional Environment
-Potential Targets within Ellipse

Eberswalde Crater

Mars Landing Site Selection Activities

Overarching Hypothesis

Sed. Delta in Crater Lake-Habitable Environment High Preservation

Setting

- Preserved Deposits in Standing Water
- Reconstruct Sed/Hydrology During Deposition, Predictive Model

Diversity

- Delta, Sinuous Ridges, Holden Megabreccia
- Two Distinct Clay Minerals

Preservation

- Clays in Bottomset Beds, Excellent Preservation Potential

Future Efforts

- Shorelines, Basin, Bottomset Bed Definition, Targets in Ellipse
- Timescale of Deposition
- Definition of Mineralogy wrt Stratigraphy
- Potential Targets Outside of Ellipse

Site Characterization

Mars Landing Site Selection Activities

Best Imaged, Best Characterized Landing Sites in Mars Exploration History

Extensive Acquisition & Analysis Orbiter Data

- Create Data Products that Address Engineering Constraints

- CDP Supports Generation of Data Products

- HiRISE DTMs & Photoclinometry, Rock Maps, Thermal Inertia, MOLA Slopes, CTX DTMs, Radar Analysis

Support Engineering Landing Simulations & Safety Analysis

- Engineering Constraints on Landing Sites

- Latitude, Elevation, Ellipse Size, Slopes (many scales),

- Rocks, Radar Reflectivity, Load Bearing (thermal inertia & albedo)

Support Traversability Analysis

- Example Traverse Timelines

Future Schedule

Mars Landing Site Selection Activities

Review/Revision of Community Summary Statements

Posted on Landing Site Websites

Project Landing Site Risk Assessment

Project Traversability Studies

Example Traverse Maps, Timelines

Opportunities for Community Involvement

5th Community Landing Site Workshop - April 2011

Science, Testable Hypotheses, Characterization, Traverses

Landing Risk, Traverse Timelines

Project Recommendation

Independent Peer Review

NASA Selection of Landing Site - Summer 2011

Launch October 2011